UNPUBLISHED
SURVEY & CONTROL
REPORTS

INTERMOUNTAIN STATION
Central Reference File
No. S.414341

RESTRICTED - FOR

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

Project | Date | Author

TITLE

THE BLACK-HEADED BUDWORM SURVEY ON THE TONGASS NATIONAL FOREST, ALASKA

Season of 1953

By

W. F. McCambridge

Bureau of Entomology and Plant Quarantine
United States Department of Agriculture

Forest Insect Laboratory
445 U. S. Court House
Portland 5, Oregon
October 30, 1953

SUBJECT—

INDEX NO.—

U. S. GOVERNMENT PRINTING OFFICE 16—47272-1

This report is not for publication in whole or in part without prior approval of the Chief of this Bureau.

FILE COPY
MISSOULA
FOREST INSECT
LABORATORY

Forest Insect Laboratory
445 U. S. Court House
Portland 5, Oregon
December 3, 1953

To : Dr. J. A. Beal, In Charge, Forest Insect Investigations, Washington 25, D. C.

From : R. L. Furniss, In Charge, Portland Laboratory, by W. F. McCambridge

Subject: Survey report - Black-headed Budworm Survey on the Tongass National Forest, Alaska. Season of 1953.

Enclosed are three copies of the above titled report. A total of 52 copies of this report have been prepared, 42 of which are being distributed immediately. Four copies of the report have been sent to the Regional Forester, Region 10.

One copy of this report has been sent to each laboratory.

cc: All stations

Enclosure

Office 1-14
Johnson
Terrell
Trostle
Denton 12/17
Evenden

BUREAU OF Entomology and Plant Quarantine
RECEIVED
DEC 4 1953
Coeur d'Alene, Idaho
Laboratory

TABLE OF CONTENTS

	PAGE
SUMMARY	1
INTRODUCTION	3
THE OUTBREAK	3
Development	3
Present Status	4
Damage	9
METHOD OF SURVEY	10
Aerial Procedure	10
Ground Procedure	11
THE BUDWORM AND ITS HABITS	12
NATURAL CONTROL FACTORS	13
ARTIFICIAL CONTROL	14
HEMLOCK SAWFLY	14
RECOMMENDATIONS	15

THE BLACK-HEADED BUDWORM SURVEY ON THE TONGASS NATIONAL FOREST, ALASKA

Season of 1953

SUMMARY

The black-headed budworm 1/ outbreak in southeast Alaska extends over practically the entire Tongass National Forest - an area of 16,073,000 acres (See map). A relatively narrow band of hemlock adjacent to the Pacific Ocean between the southern tip of Baranof Island and the southern tip of Prince of Wales Island has escaped noticeable budworm damage. The remainder of the hemlock forests have suffered various degrees of defoliation, in some instances heavy enough during the past few years to cause over fifty percent crown length kill to the majority of stems within the stands. Fortunately, such heavy crown defoliation extends over a very small fraction of the hemlock forests; some 6,600 acres.

Prior to 1953, defoliation of hemlock by the budworm had been very heavy throughout approximately 8,000,000 acres of the Tongass National Forest south of Frederick Sound. North of the sound, budworm feeding was light but extended over an additional 3,600,000 acres. During the summer of 1953, defoliation of hemlock forests was very heavy north of Frederick Sound, throughout Admiralty Island and on the mainland north to Juneau. This very heavy defoliation occurred in scattered areas within 1,500,000 acres. South of the Sound, budworm activity was subsiding.

Coupled with the light budworm defoliation south of Frederick Sound was much evident feeding by the hemlock sawfly 2/. The sawfly, which has been especially noticeable on the east side of Prince of Wales Island for the past three years, appears to have increased its range and severity and has now been found in scattered epidemic proportions between Ketchikan and Petersburg, an area of approximately 4,000,000 acres (See map).

1/ Acleris variana, Fernald

2/ Neodiprion tsugae, Middelton

During September and early October, 1953, Forest Service personnel submitted samples of hemlock foliage from widely scattered locations on both the Chugach and Tongass Forests. These samples were submitted during and after budworm oviposition for the purpose of determining an estimate of the defoliation that could be expected in 1954. As the samples of hemlock foliage were received, budworm egg counts were made and the following conclusions reached.

1. Black-headed budworm feeding in 1954 will be much lighter than that which occurred in 1953.

2. Budworm feeding will be generally light throughout most of the region south of Frederick Sound.

3. North of Frederick Sound, defoliation in 1954 will be lighter than that which occurred in 1953, but diversified conditions will prevail as follows:

   (a) Budworm feeding will be relatively light, but noticeable in the Juneau area. Some pockets of moderate defoliation will be found within the vicinity of the town.

   (b) Budworm feeding will be relatively light on the east side of Baranof and Chichagof Islands, and throughout much of Admiralty Island. There will be scattered areas of moderate and possibly heavy feeding on portions of Baranof, Chichagof and Admiralty Islands and within the Lynn Canal area.

   (c) Some very noticeable budworm defoliation of spruce and hemlock is expected in the Skagway area.

Experimental tests using DDT water emulsions and oil solutions, applied by hand methods, gave excellent control of budworm and sawfly larvae.

INTRODUCTION

Outbreaks of the black-headed budworm have appeared at irregular intervals throughout the hemlock forests of southeastern Alaska for many years. One of the earliest recorded outbreaks occurred in 1919, and since that time other more localized epidemics have been observed. No detailed record of the nature and extent of these outbreaks is available.

The current black-headed budworm outbreak on the Tongass National Forest has been present for the past five years. Not until the fall of 1952, when funds became available under the Forest Pest Control Act, was it possible to make a relatively large scale survey of the outbreak. The major emphasis of the survey in 1952 was to locate the areas of heaviest infestation. In 1953, a combination of widespread ground samples and intensive aerial observations of areas not covered in 1952, produced a more complete picture of the present budworm epidemic. The 1953 survey was a cooperative effort between the Forest Service and the Division of Forest Insect Investigations of the Bureau of Entomology and Plant Quarantine.

To all Forest Service personnel in Region 10 must go the credit for obtaining the widely scattered foliage samples from which were made the estimates of the present status of the outbreak. The Bureau of Entomology and Plant Quarantine also acknowledges the wholehearted and most satisfactory cooperation extended us in the form of working facilities and boat and vehicle transportation. Acknowledgement is also given the Division of Forestry of the Bureau of Land Management and the Skagway Chamber of Commerce who provided transportation and field personnel at Haines and Skagway.

THE OUTBREAK

Development

The present black-headed budworm outbreak appears to have started about 1948, possibly in a number of more or less isolated locations throughout the southern half of the Tongass National Forest. In that year, a small infestation was seen on western hemlock at the mouth of Anan Creek on the mainland southeast of Wrangell Island. By 1950, the infestation was widespread and much in evidence in the Twelve Mile Arm on Prince of Wales Island, and northeast to the Bradfield Canal. During late summer of 1951, H. E. Anderson and I. H. Jones reported having seen heavy budworm feeding at various locations from Petersburg to Gedney Pass on Revillagigedo Island and over most of Prince of Wales Island. From these accounts and observations made in 1952, it is believed that by the end of 1951, the black-headed budworm had reach epidemic proportions over the area from the Portland Canal northwestward to the Admiralty Lakes Region on Admiralty Island - an area of about 8,000,000 acres.

In 1952, tremendous moth flights were observed between Ketchikan and Juneau, and the epidemic spread over the entire Tongass forest with the exception of a narrow band of hemlock adjacent to the Pacific Ocean between the southern tip of Baranof Island and the southern tip of Prince of Wales Island. The outbreak extended from the Portland Canal to Skagway. A light epidemic of the budworm was also present in the Yakutat area.

Present Status

In June, 1953, hemlock forests on the Tongass National Forest north of Frederick Sound were green and normal in appearance with the exception of a few browned areas in the vicinity of Admiralty Lakes. South of Frederick Sound were thousands of acres of brown hemlock forests, some of which contained a high percentage of dead tops as a result of previous budworm feeding. As the summer wore on the presence of the budworm became very evident in the browning of the forests on Admiralty Island and on the mainland between Frederick Sound and Juneau. Scattered stands of hemlock also began to appear brown on the east side of Baranof and Chichagof Islands. These areas of brown colored forests, representing heavy defoliation, extended throughout approximately 1,500,000 acres. Patches of moderately defoliated forests extended north of Juneau to Berner's Bay, but the remainder of the hemlock in the Lynn Canal suffered light budworm feeding, and off-color foliage was not apparent. Spruce and hemlock were also suffering light defoliation in the Yakutat area. Between Juneau and Point Hugh on the southern tip of the Glass Peninsula, Sitka spruce had become alarmingly brown as a result of budworm feeding. Close examination revealed that the 1953 growth had been killed. In only a very few instances had the budworm feeding reached back to kill the 1952 needle growth. Western hemlock, on the other hand, often suffered the loss of approximately eighty percent of its total needle complement, regardless of the age of the needles. While this heavy budworm feeding was taking place during June and July in the forests north of the Frederick Sound, hemlock stands in the areas of previous heavy feeding were suffering only light defoliation. Ground examinations at Ketchikan, Petersburg, and various locations on Prince of Wales Island revealed the presence of light epidemic numbers of budworm larvae. On the other hand these ground examinations and extensive aerial appraisal work which followed revealed a heavier epidemic of the hemlock sawfly.

The tremendous budworm populations which caused such heavy defoliation of the hemlock forests north of Frederick Sound did not produce a very noticeable number of moths. In September of 1952, moths were so numerous in the air between Juneau and Petersburg that they created a real nuisance to pilots when they become so heavily coated on windshields as to obstruct visibility. No such moth flight was noticed in 1953 over the same area. The only heavy moth flight observed was on September 15 while flying over the southern half of the west shore of Admiralty Island.

Coupled with an apparent reduction in the magnitude of the moth flight, there appears to be a general reduction in the number of eggs deposited on hemlock foliage. In no instance was it possible to find a comparable egg concentration similar to that deposited in 1952. Table I which follows presents the egg count data collected from twig samples cut during September and early October of 1953.

TABLE I

BLACK-HEADED BUDWORM EGG COUNT DATA COLLECTED FROM HEMLOCK TWIG SAMPLES CUT ON THE TONGASS NATIONAL FOREST - FALL OF 1953

	Location	No. of 10" Twigs in Sample	Twig Inches of Needles	Eggs	Eggs per Twig Inch of Needles	Date Sample Collected	Remarks
Budworm defoliation in 1954 expected to be moderate or heavy. Location numbers are shown in red on the map.							
1	Skagway	18	466	97	.21	Sept. 24	
	Skagway	12	306	162	.53	Sept. 24	Sitka spruce twigs
2	Bridget Cove	30	1005	231	.23	Sept. 2	Oviposition not completed
5	Juneau-Mile 12.5	30	627	119	.19	Sept. 25	
10	Juneau-Gold Creek	30	482	248	.52	Sept. 24	
11	Juneau-Gold Mine	30	704	199	.29	Sept. 23	
16	Taku River	20	740	79	.11	Sept. 21	
18	Marble Bluff	30	870	115	.13	Sept. 12	Some sawfly feeding
25	Tenakee Springs	30	811	173	.21	Sept. 13	
30	Poison Cove	29	971	165	.17	Sept. 29	
Budworm defoliation in 1954 expected to be light. Location numbers are shown in black on the map.							
3	Juneau-Mile 18.5	30	708	9	.01	Sept. 25	
4	Juneau-Mile 15.5	30	785	7	.01	Sept. 25	
6	Juneau-Mile 9.5	30	820	74	.09	Sept. 24	
7	Juneau-Mile 6.5	30	619	39	.06	Sept. 24	
8	Juneau-Mile 3.5	30	731	49	.07	Sept. 24	Some sawfly feeding
9	Juneau-Mile 0.5	30	475	46	.10	Sept. 23	
12	Thane	30	923	1	.00	Sept. 23	Some moderate sawfly feeding

Continued

TABLE I (Continued) Black-headed Budworm Egg Count Data Collected from Hemlock Twig Samples Cut on The Tongass National Forest - Fall of 1953.

	Location	No. of 10" Twigs in Sample	Twig Inches of Needles	Eggs	Eggs per Twig Inch of Needles	Date Sample Collected	Remarks
13	Douglas	30	550	27	.05	Sept. 28	Some sawfly feeding
	Douglas	15	304	8	.03	Sept. 28	Sitka spruce twigs
14	Douglas-Mile 1.3	30	625	16	.03	Sept. 28	
	Douglas-Mile 1.3	14	691	3	.00	Sept. 29	Sitka spruce twigs
15	Douglas-Mile 4.3	30	454	13	.03	Sept. 28	
	Douglas-Mile 4.3	15	434	3	.01	Sept. 28	Sitka spruce twigs
17	Hawk Inlet	30	1004	10	.01	Sept. 18	Some light sawfly feeding
19	Fishery Creek	30	925	30	.03	Sept. 14	Heavy sawfly feeding
20	Admiralty Lakes	30	1101	17	.02	Sept. 7	Oviposition not completed
21	Thayer Creek	30	1378	8	.01	Sept. 11	" "
22	South Arm of Kootznahoo Inlet	30	1120	39	.03	Sept. 10	" "
23	South Arm of Hood Bay	30	1481	4	.00	Sept. 9	" "
24	North of Point Gardner	30	2033	44	.02	Sept. 8	" "
26	White Rock	29	869	12	.01	Sept. 4	" "
27	Lindenberg Head	30	822	10	.01	Sept. 3	" "
28	Sitkoh Lake	30	993	4	.00	Sept. 2	" "
29	Takatz Bay	30	1673	12	.01	Sept. 5	" "
31	Fish Bay	16	336	27	.08	Sept. 29	
32	Jamestown Bay	30	937	163	.17	Sept. 30	
33	Petersburg	30	630	20	.03	Oct. 2	Some sawfly feeding
34	Eagle River	8	95	1	.01	Sept. 21	
35	Stone Island	8	367	0	.00	Sept. 19	
36	Hollis	30	858	7	.01	Sept. 15	Moderate sawfly feeding
37	Skowl Arm	5	82	1	.01	Sept. 16	Heavy sawfly feeding
38	Ketchikan	30	1016	127	.13	Oct. 5	Some sawfly feeding
39	Gravina Island	30	1197	68	.06	Oct. 5	

The significance of the mean egg counts (eggs per twig-inch of needles) found in 1953,and listed in Table I is difficult to interpret in terms of defoliation which can be expected in 1954. Egg counts made in the fall of 1952 at Hollis, Ketchikan and Petersburg were not associated with serious larval feeding in 1953. These egg counts were .02, .03 and .03 eggs per twig-inch respectively.

In April of 1953, a series of study plots were established at Juneau in an attempt to determine the amount of defoliation which could be expected from larvae emerging from various known budworm egg deposits. At the time the plots were established, the budworm eggs were still dormant and were assumed to represent the true population of the 1952 eggs.

In the first series of plots, young stands of open grown reproduction were sampled and the following results obtained.

Lemon Creek, Juneau. The 1952 egg deposit of 2.27 eggs per twig inch of hemlock needles resulted in the following 1953 defoliation. Most of the largest spruce suffered 100 percent defoliation of 1953 needle growth throughout the upper half of the crown. Most of the largest hemlock suffered 100 percent defoliation throughout the upper half of the crown; however, a few large hemlock escaped very noticeable damage. Most of the intermediate sized hemlock suffered complete or scattered complete defoliation within the upper third of the crown.

Montana Creek, fifteen miles north of Juneau. The study plot of open grown reproduction harbored 1.19 eggs per twig inch of hemlock needles in 1952. This deposit produced the following defoliation. Almost all of the 1953 growth on Sitka spruce was devoured in the upper half of the crown. On hemlock, the tallest and most open crowned trees suffered 100 percent defoliation of all needle growth throughout the upper half of the crowns. Budworm defoliation on the smaller trees was scattered, both between trees and between branches on any one tree.

Douglas. The study plot of open grown reproduction contained .27 eggs per twig inch of hemlock needles. This deposit produced general browning of the upper third of the crowns of the largest trees, and considerable scattered complete tip defoliation among the lateral branches.

In the second series of plots suppressed trees of reproduction size, growing under a full mature forest canopy, were established and the following results obtained.

TABLE II

HEMLOCK DEFOLIATION CAUSED BY KNOWN CONCENTRATIONS OF BLACK-HEADED BUDWORM EGGS

Location	1952 Eggs per twig inch of needles 1/	Percent defoliation on Terminal Ten-inch Twigs 2/
Lemon Creek #1	.04	16
Lemon Creek #2	.06	22
Lemon Creek #3	.06	25
Lemon Creek #4	.07	21
Montana #1	.05	16
Montana #3	.06	20
Douglas #3	.09	23

1/ Egg counts from 160 ten-inch twigs cut from the terminal ends of lateral branches in the upper one third of the crown. Eight ten-inch twigs cut from each tree.

2/ Defoliation measurements from 160 ten-inch twigs cut from the terminal ends of lateral branches in the upper one third of the crown. Eight ten-inch twigs cut from each of the same trees from which egg count twigs were cut.

The ten-inch twigs used in this study contained from one to three years of needle growth, and were the portion of the tree most susceptible to budworm defoliation. Very little defoliation was present on the trees sampled beyond these ten-inch twigs; therefore, the removal of up to 25 percent of the foliage on ten-inch twigs does not constitute serious budworm defoliation to the tree as a whole. In fact, in September, 1953, when these trees were examined all of the trees used in this study looked quite green and healthy, with the exception of the suppressed trees at Douglas #3. These trees contained a number of scattered brown needle clusters and showed obvious defoliation.

From the above discussion it can be seen that egg deposits of .27 or more eggs per twig inch of hemlock needles were associated with noticeable defoliation of hemlock and spruce. On the other hand, egg deposits of .09 or less eggs per twig inch of needles did not cause alarming defoliation. Therefore, until more information can be obtained, we have arbitrarily set .11 eggs per twig inch of hemlock needles as the minimum deposit which will be associated with obvious budworm defoliation and noticeable off-color foliage and twigs.

Your attention is again called to Table I. In this table, location number 38, Ketchikan, with an egg deposit of .13 is not considered serious because of the abundance of egg parasites found at the sampling locality. Mountain hemlock (Tsuga mertensiana (Bong.) Sarg.) twig samples received from the Kenai peninsula and Cordova on the Chugach National Forest contained only one budworm egg. For this reason these twig measurements have not been included in Table I.

Damage

Repeated budworm defoliation south of Frederick Sound has resulted in extensive top kill of hemlock. Such top kill is most prevalent between Petersburg and Ketchikan, and west on Prince of Wales Island.

The following is taken from a special report by F. T. Hutchison.

> "An aerial appraisal of black-headed budworm damage was made in early August. The areas covered by the survey included: Ketchikan Pulp Company Sale Area on Prince of Wales Island with the exception of the northwest section - Shakan Bay to Warm Chuck, all of Revillagigedo Island, Etolin Island, Wrangell Island and the northwest and southeast sides of Cleveland Peninsula. (Note: This area lies roughly within the area shown on the map covered by the hemlock sawfly epidemic.)
>
> "The mapping included two categories of damage to the hemlock forests: (1) where less than fifty percent of the crown length was dead, and (2) where more than fifty percent of the crown length was dead. Mapping included only those hemlock stands in which at least fifty percent of the stems had sustained some degree of top kill."3/
>
> "Hemlock with more than fifty percent dead crown length covers 6,600 acres. The total gross volume of hemlock on these acres is 105,124,000 feet b.m. Hemlock with less than fifty percent dead crown length covers 11,768 acres. The total hemlock volume on these acres is 180,271,000 b.m."
>
> "There are some additional large areas of hemlock with various degrees of top kill affecting less than fifty percent of the stems in any given stand. These areas are especially noticeable at Chomley Sound, Polk Inlet, Dry Pass, Red Bay and the the northwest side of Prince of Wales Island. There are also such areas on Busby Island, south side of Zarembo Island and the north and east sides of Revillagigedo Island."

3/ The aerial appraisal work was confined to the forests within two miles of salt water. No serious defoliation of spruce was seen.

The very heavy defoliation of hemlock forests which occurred in 1953 north of Frederick Sound resulted in the loss of considerable hemlock foliage in stands scattered throughout Admiralty Island, and on the mainland between the Sound and Juneau. It is estimated that some hemlock stands lost up to eighty percent of their foliage during this one year of feeding. Damage to spruce throughout these areas was confined, for the most part, to the 1953 needle growth.

Hemlock trees which were so heavily stripped of foliage put out a second crop of needles and by the first of October, forests had greened up to a considerable extent. A new needle crop on spruce was not evident. Feeding on the 1953 spruce needle growth was not confined entirely to the needles. The budworm often continued to feed on the outer tissues (cortex) of the twig. As the dead spruce needles fell off the twig ends, the thin dead twigs could be seen protruding spike-like all over the trees. Twigs of hemlock were not damaged by budworm feeding.

General timber stand damage, attributed to budworm feeding, exhibited a wide range of variation. In the first series of study plots used to measure the amount of larval feeding resulting from known egg deposits, the stands of open grown reproduction suffered much heavier defoliation than adjacent mature forest trees. Truly suppressed trees in the second series of plots suffered much lighter defoliation than did the adjacent overtopping mature trees. Within some hemlock stands on well drained slopes, mature trees suffered heavier defoliation than both suppressed trees and young, open grown reproduction. On some plots intermediate trees suffered heavier defoliation than that occurring on dominant trees. These and other variations of damage require further study to understand the full range and significance of such defoliation.

METHOD OF SURVEY

Aerial Procedure

In 1952, the forests between the Portland Canal, Frederick Sound, British Columbia and the west side of Prince of Wales Island were covered by extensive aerial survey. This survey incorporated a combination of grid and contour flight lines and was extended over a very high percentage of the forested areas within the boundaries of the survey.

In 1953, survey funds were restricted and the aerial survey work was reduced. A cooperative arrangement between the Fish and Wildlife Service and the U.S.Forest Service was used to advantage when Forest Service personnel of the Alaska Forest Research Center invited Bureau personnel to fly over Chicagof and Baranof Islands. This flight took place on July 22 and covered the peripheral areas of the two islands.

During early August, an aerial appraisal of budworm damage was made over areas previously mentioned in this report (See page 9 under "Damage") On this flight current budworm damage was mapped when accompanied by hemlock top kill.

On September 15, a light plane was chartered and the budworm infestation mapped by contour flying south of Juneau to Endicott Arm; around the southern tip of Admiralty Island and up the west coast; westward on Chichagof Island adjacent to Icy Strait; over to the mouth of Glacier Bay on the Glacier National Monument, and then back to Juneau. Additional epidemic areas were mapped when on regular scheduled flights from Juneau to Petersburg, and Juneau to Skagway.

As a result of the aerial surveys carried out in 1952 and 1953, the extent of the black-headed budworm outbreak is rather well known. However, much ground work was necessary to verify the aerial findings and furnish more detailed information on the present status of the outbreak.

Ground Procedure

The assistance of all Forest Service personnel engaged in field work was heavily relied upon to furnish ground sampling data.

During the larval period of the budworm, foresters reported the presence or absence of the insect at all shore calls made by them. Larval and pupal collections were made at Hyder at the head of the Portland Canal, Ketchikan, Hollis and Petersburg.

On September 1, all field personnel of the Tongass and Chugach forests were requested to send twigs of hemlock foliage to Juneau so that egg counts could be made. Unfortunately, the budworm was slow in developing in some areas so that some of the egg count data are not conclusive. It was requested that field parties send in thirty ten-inch twigs cut from at least six open grown trees of reproduction size. Such samples were to be taken at every possible location. The response from this request was most gratifying. The collection of twig samples was greatly enhanced by the activities of personnel from the Alaska Forest Research Center. These men were engaged in widespread timber review activities which enabled them to submit samples from a great many locations which otherwise would not have been visited.

The results of this extensive sampling have been presented in Table I.

THE BUDWORM AND ITS HABITS

The black-headed budworm completes its life cycle in one year. Moths deposit the small, oval yellow eggs singly on the underside of western hemlock and Sitka spruce needles during September and early October and the winter is passed in this stage. Western hemlock is the preferred host. The moths seem to prefer to deposit their eggs near the tips of branches in the upper crown.

As the buds near the completion of their swelling and begin to open, the eggs hatch and the tiny yellow larvae mine into the expanding buds and begin to feed. Sometimes this early feeding kills the buds. When this happens, the budworm larvae move to other buds. At other times the buds outgrow this initial feeding and normal growth develops. As twig growth continues, the larvae continue to develop, feeding first on the new needle growth. When this supply is exhausted they begin to feed on the older foliage. Needles are usually webbed together and the larvae feed while protected by this webbed cluster of needles. Often times the mid-rib of the needle is partial eaten. This kills the needle which eventually turns brown and contributes much toward the off-color appearance of heavily defoliated hemlock and spruce trees. There appear to be six larval instars. During the first five the budworm is yellow to light green in color and the head is black. In the last instar the head is tan in color and the body is usually light green. When full grown the larvae are almost an inch long. The larval period lasts from 6 to 8 weeks, but weather exerts some influence on the rapidity of development. Larval development seems to be more rapid on spruce than on hemlock. On June 22, 1953, thirty-five percent of the larvae on a Sitka spruce had reached the last instar, whereas only one percent of the larvae on a nearby hemlock of the same size and exposure had reached that stage of development.

Pupae of the budworm are usually dark shiny brown but sometimes greenish-brown, and about five-sixteenths of an inch long. They are found within the webbed clusters of needles. The pupal stage lasts about three weeks.

Budworm moths are usually gray, but exhibit a wide variety of colors and markings. The moth is small, about three-eighths of an inch long and one-fourth inch wide. Moths begin to appear in August, but once again, weather may exert some influence on the date of emergence. For some time after emergence the moths seem content to remain quietly on the trees where they had developed. During the time of egg laying moths appear to be strong fliers and seem little affected by heavy rains.

NATURAL CONTROL FACTORS

The numerous factors exerting natural control of the budworm outbreak have not been given adequate study. Such factors as parasites, predators, birds, disease and adverse weather conditions all contribute in varying degrees at various locations to the control of the outbreak.

Samples taken at Ketchikan where the budworm has been present for about two years revealed that 22 percent of the eggs were parasitized by Trichogramma sp. Twenty-seven percent of third and fourth instar larvae were dead from a combination of causes believed to be disease and parasites. It was not possible to collect pupae from Ketchikan, but it is expected that pupal mortality was high in view of the number of parasitic wasps seen in the area.

At Hollis and Petersburg where the budworm outbreak has been present for two or more years, a sample of 1000 eggs taken at each location revealed egg parasitism of only 2.6 and .6 percent respectively. Third and fourth instar larvae collected at Petersburg revealed 27 percent mortality from causes believed to be disease and parasites.

Samples taken at Juneau where the budworm had reached outbreak proportions this year revealed only .9 of one percent parasitism by Trichogramma sp. Third and fourth instar larval mortality from factors believed to be disease and parasites was only one percent. However, it was very evident that mortality from parasites and disease varied greatly within very short distances. A small area at the southern tip of Douglas Island was examined and within the area no living larvae could be found. The larvae, which had reached the last instar exhibited the following characteristics: dry and shriveled, discolored and soft, liquefied and structureless, and extreme fragility of skin.

Pupae were collected from a number of areas and placed in gelatin capsules for moth emergence. The following results were obtained.

TABLE III

BUDWORM MOTH EMERGENCE FROM PUPAL COLLECTIONS
TAKEN FROM UNCAGED HEMLOCK TREES

Location	No.of Pupae	Pupae with no Emergence No.	Percent	Parasites No.	Percent	Moths Emerged No.	Percent
Juneau	130	66	51	27	21	37	28
Juneau-Mile 7	67	33	49	12	18	22	33
Juneau-Lemon Cr.	290	77	26	37	13	176	61
Juneau-Montana Cr	251	100	40	51	20	100	40
Petersburg	113	65	57	35	31	13	12

Emergence studies by R. L. Furniss carried out during a black-headed budworm epidemic on the Olympic Peninsula in Washington some years ago also revealed a high percentage of non emergence. This condition seems normal to the black-headed budworm. It is noted that pupae which do not produce moths are significantly smaller than those pupae which do produce moths.

The parasitic wasps which emerged from the pupae collected have not been identified. At the same time that pupae were collected to determine the percentages of parasitism and moth emergence, additional pupal collections were made from muslin caged trees for tests to determine the egg laying capacity of the budworm. These pupae were placed singly in gelatin capsules for moth emergence. One male and one female were then placed on each of twenty small caged hemlock trees.

The results of this test were as follows: ten pairs - 0 eggs, six pairs - 1 to 10 eggs, three pairs - 20 to 30 eggs, one pair - 70 eggs. These results do not necessarily indicate low budworm fecundity, but rather, that the technique is in need of refinement.

Birds have been observed devouring large quantities of budworm larvae. How effective this feeding has been is not known, nor were the species of birds involved recognized by the author.

ARTIFICIAL CONTROL

During the summer, spray tests against mid-instar budworm larvae were conducted. DDT in oil solutions and water emulsions were used in these hand spray tests. Excellent control was obtained with 1.90 and 6.25 percent water emulsions of DDT. An oil solution of 6.25 percent DDT gave excellent control of mid-instar budworm larvae, but a concentration of 1.9 percent DDT resulted in uncertain control and additional tests need to be made.

All concentrations of DDT, whether in oil or water, gave quick and excellent control of sawfly larvae which happened to be on the foliage.

HEMLOCK SAWFLY

The hemlock sawfly has been present in widely scattered epidemic proportions throughout areas of previous heavy black-headed budworm feeding for the past few years. In 1952, the sawfly was noticed as epidemic at Ketchikan, Polk Inlet, McKenzie Inlet both on Prince of Wales Island, and at Petersburg. It is believed that many additional epidemic centers existed at this time.

No formal sawfly detection survey was conducted in 1953. However, much of the area outlined on the map as harboring sawfly epidemics was covered by aerial survey in conjunction with the appraisal of budworm damage. During this appraisal, heavy sawfly defoliation was evident on Prince of Wales Island from Chomley Sound to the northern extent of the island. Such heavy damage seemed confined for the most part, to the eastern side of the island. H. E. Anderson of the Alaska Forest Research Center reports possible kill of hemlock in the Chomley Sound area as a result of heavy sawfly feeding following previous budworm defoliation.

Additional areas of heavy sawfly feeding were observed during the budworm appraisal survey between Ketchikan and Petersburg.

While we believe that scattered epidemic centers of the hemlock sawfly are prevalent throughout some 4,000,000 acres, the actual area of serious defoliation is only a fraction of this size. Unfortunately, specific information on the extent and severity of the epidemic centers is lacking.

In reference to Table I, it will be noted that the sawfly was present on twigs sent in from widely scattered locations. Only at Marble Bluff-Fishery Creek and at Hawk Inlet on Admiralty Island was the evidence of sawfly feeding general enough to be considered a light epidemic. The evidence of sawfly on twigs received from other locations outside of the estimated boundary of the sawfly epidemic was too light to consider serious at this time. However, it must be remembered that the sample of the Tongass Forest is very small for accurate location estimates of the sawfly.

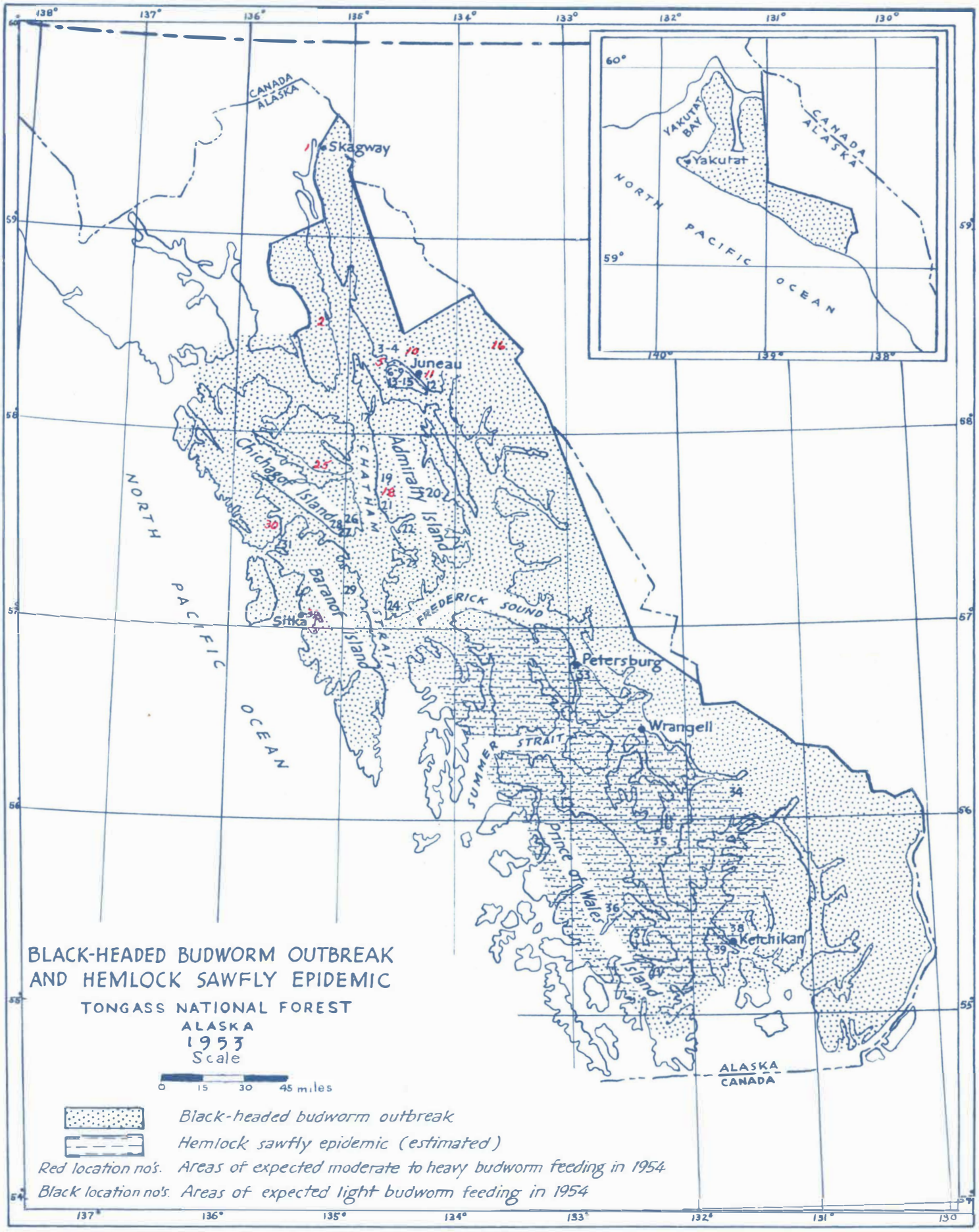
RECOMMENDATIONS

1. No direct control is recommended against either the budworm or the sawfly.

2. It is recommended that experimental tests of aerial sprays of DDT be conducted. Tests against the budworm should be carried out in the Juneau area. Tests against the sawfly should be carried out in the vicinity of Ketchikan.

3. Studies of the black-headed budworm and hemlock sawfly should be continued to determine:
   (a) host-budworm relationships, (b) natural control factors and their effects on the outbreaks, and (c) evaluations of population densities.

4. Surveys of the black-headed budworm and hemlock sawfly outbreaks should be conducted in 1954.


BLACK-HEADED BUDWORM OUTBREAK
AND HEMLOCK SAWFLY EPIDEMIC
TONGASS NATIONAL FOREST
ALASKA
1953
Scale
0 15 30 45 miles
Black-headed budworm outbreak
Hemlock sawfly epidemic (estimated)
Red location no's. Areas of expected moderate to heavy budworm feeding in 1954
Black location no's. Areas of expected light budworm feeding in 1954
CANADA
ALASKA
Skagway
Juneau
Sitka
Petersburg
Wrangell
Ketchikan
Chichagof Island
Admiralty Island
Baranof Island
Prince of Wales Island
CHATHAM STRAIT
FREDERICK SOUND
SUMMER STRAIT
NORTH PACIFIC OCEAN
YAKUTAT BAY
Yakutat
ALASKA
CANADA